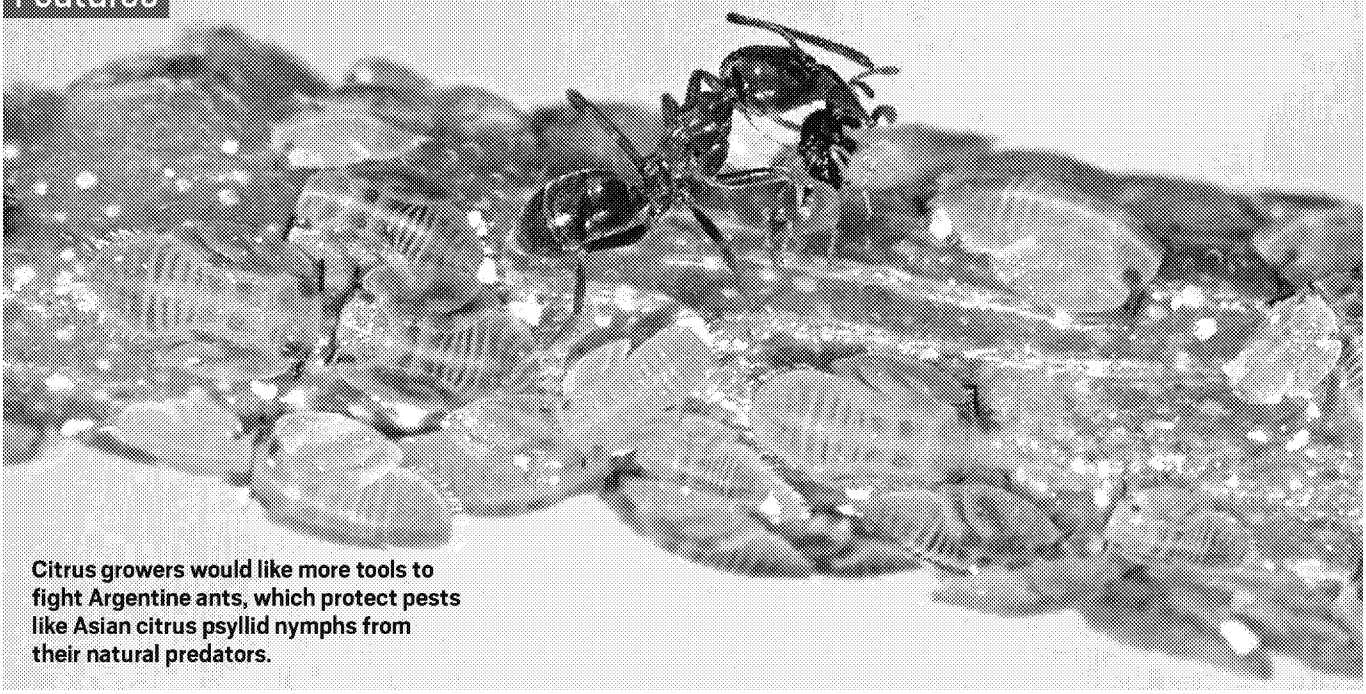


Citrus growers would like more tools to fight Argentine ants, which protect pests like Asian citrus psyllid nymphs from their natural predators.

PESTICIDES

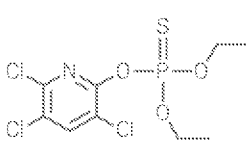
Life after chlorpyrifos

Alternatives exist to control most crop pests, but a few situations remain problematic

BRITT E. ERICKSON, C&EN STAFF

The insecticide chlorpyrifos is on its way out, the result of growing concerns about organophosphate compounds that were first developed as nerve gas weapons in World War II and later adapted to become commercial pesticides.

The loss is leaving growers scrambling. A broad-spectrum insecticide that kills all arthropods in its path, chlorpyrifos was used for decades throughout the US to combat a wide array of insects on corn, soybeans, citrus, tree nuts, alfalfa, and many other crops. But use has declined steadily since a 1996 law raised safety standards to protect children against possible neurodevelopmental effects.



Chlorpyrifos

The US Department of Agriculture estimates that 3 million–5 million kg of chlorpyrifos was used in the US in 2014. California—once the number 1 state for chlorpyrifos use—applied nearly 600,000 kg that year to control several dozen insects on about two dozen crops. But nearly all uses of chlorpyrifos will be prohibited in California at the end of this year.

A full US ban may be coming, depending on the outcome of a lawsuit and the upcoming presidential election. Sales of chlorpyrifos ceased in the European Union at the end of January 2020. Citing low demand, Corteva Agriscience, the largest manufacturer of chlorpyrifos, announced in early February that it will phase out production of the chemical this year.

Growers can get a handle on most pests without chlorpyrifos by using other commercial pesticides and pest management practices. In a few situations, however, managing insects without chlorpyrifos is a challenge. Most newer pesticides are designed to kill specific pests, making it tough to find alternatives for every application of chlorpyrifos.

Earlier this year, a panel of experts convened by the California Department of Pesticide Regulation (DPR) published a list of alternative pesticides to chlorpyrifos and longer-term pest control options for numerous crop-pest combinations. In cases in which only a couple of or no alternatives exist, DPR is funding research to help find solutions.

Baiting orchard ants

One of those cases is sugar-feeding ants, including Argentine and native gray ants, in citrus and grape orchards. Ants are a problem in orchards because they protect sap-sucking pests, such as aphids and the Asian citrus psyllid, from natural enemies like hoverflies. These sap-sucking pests often carry bacteria that cause citrus diseases.

No chemical alternatives to chlorpyrifos exist for controlling these pests in citrus orchards, and only two chemicals are approved for use in ant bait stations in grape orchards. DPR provided a total of $1.34 million in late August to three California researchers to find alternatives to chlorpyrifos for controlling ants in citrus and grape orchards.

Mark Hoddle, a biological-control

CREDIT: MIKE LEWIS/UC RIVERSIDE

specialist and principal investigator at the University of California, Riverside, received one of those grants to investigate alternatives for managing Argentine ants in citrus orchards.

Hoddle and colleagues are testing biodegradable hydrogel beads that act as miniaturized liquid baiting stations. The researchers soak the beads, made from alginate, in an aqueous solution containing 25% sucrose and a small amount (0.0001%) of a water-soluble insecticide. Once the beads absorb the solution, the researchers scatter them under citrus trees.

"The ants find them, drink the liquid sugar, and take it back to the nest," Hoddle says. The ants feed the insecticide-laced sugar water to the queens and other workers, poisoning the colony. The advantage of the hydrogel beads is that they degrade into the soil after 2–3 days, so you don't have to retrieve them, wash them, and refill them, Hoddle notes. You just put out another batch a couple of weeks later, he says.

The team is testing eight insecticides that can be absorbed by the beads to determine if they are effective at ultralow concentrations. Hoddle won't disclose which insecticides his group is testing but says they are commercially available products that are water soluble and have ant activity.

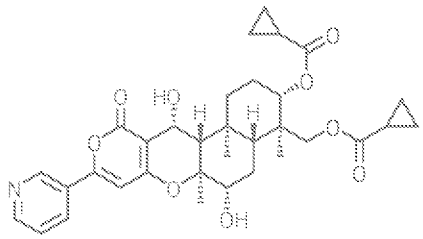
Hoddle's group is also experimenting with planting small plots of alyssum to attract hoverflies and other natural enemies of sap-sucking pests in citrus orchards. "If we have a good natural enemy in our citrus orchards controlling the target pest, then we don't need to use insecticides as frequently," Hoddle says.

Stopping sticky cotton

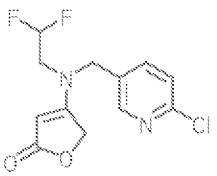
Aphids are not just a problem in citrus orchards. They also produce a sticky, sugary residue on cotton. Sugar-contaminated cotton "can lead to big problems with processing," says Ian Grettenberger, a cooperative-extension specialist at UC Davis and UC Agriculture and Natural Resources.

Grettenberger is leading a DPR-funded project to test alternatives to chlorpyrifos for controlling aphids and other piercing and sucking insects, like whiteflies, on cotton. The researchers plan to test commercially available insecticides and products under development using various spray settings, application rates, and frequencies.

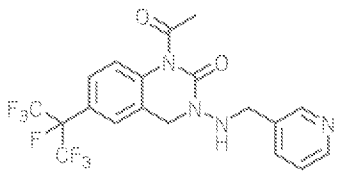
The project will focus on three insecticides: flupyradifurone, marketed by Bayer Crop Science under the name Sivanto; afidopyropen, marketed by BASF as Sefina; and pyrifluquinazon, marketed by Nichino America as PQZ. The companies claim that these newer pesticides target piercing and sucking insects without harming pollinators and beneficial insects. The pesticides are also promoted for controlling aphids that are resistant to neonicotinoids and pyrethroids, two classes of pesticides often used as alternatives to chlorpyrifos.



Afidopyropen



Flupyradifurone



Pyrifluquinazon

The neonicotinoids imidacloprid and acetamiprid, and a similar pesticide called flonicamid, can be used to control aphids on cotton, Grettenberger says. Likewise, the neonicotinoids thiamethoxam and acetamiprid and several other insecticides, including growth regulators, are useful for controlling whiteflies on cotton, he says. But those pesticides are not the focus of the DPR-funded project, he notes.

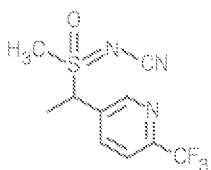
Neonicotinoids are often touted as a safer alternative to organophosphate pesticides like chlorpyrifos, but they are under intense scrutiny for their potential to harm bees and other pollinators. Additionally, some insect pests are starting to show resistance to neonicotinoids.

Combating alfalfa pests

Resistance is a big problem with pyrethroids, which "have been the go-to option" for controlling alfalfa weevils, Grettenberger says. Growers turned to chlorpyrifos when they faced both aphids and weevils on alfalfa.

Two types of pesticides—indoxacarb, marketed by FMC as Steward, and pyrethroids—are available for weevil control in alfalfa, says Rachael Long, a UC Cooperative Extension farm adviser. Because of the problem of pyrethroid resistance in weevils, having only two active ingredients "leaves us in a very risky area," she says.

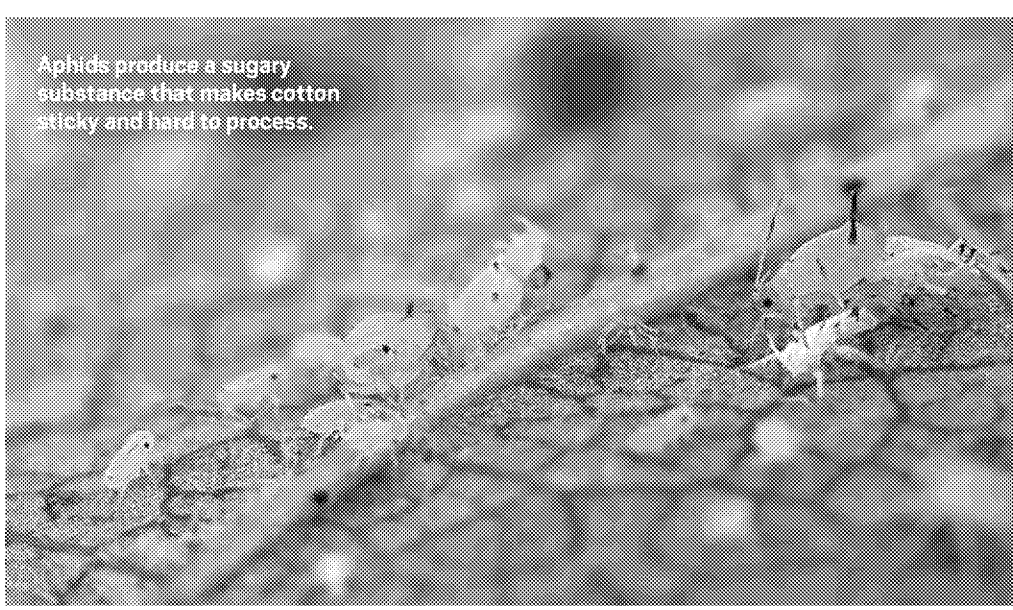
For aphids, a handful of pesticides are available, including flupyradifurone and the organophosphate malathion, Long says. Afidopyropen and pyrifluquinazon likely will have registrations soon, but they are not yet approved in California for use on alfalfa, Grettenberger says.



Sulfoxaflor

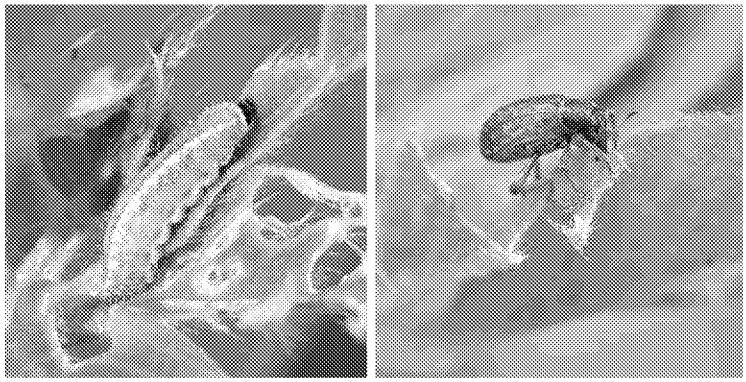
Sulfoxaflor is also an option to control aphids on alfalfa in some counties in California. Growers are pushing California to approve it for additional counties. The pesticide is marketed by Corteva under the name Transform.

Some of these newer pesticides are just as harmful to bees as neonicotinoids, environmental groups claim. France banned



Aphids produce a sugary substance that makes cotton sticky and hard to process.

CREDIT: IAN GRETTENBERGER/UC DAVIS



Only two pesticide active ingredients are currently available to control alfalfa weevils. Weevil larvae (left) cause more damage to crop leaves than adult weevils.

CREDIT: IAN GRETTENBERGER/UC DAVIS

the use of flupyradifurone and sulfoxaflor earlier this year because of concerns about harming bees.

Sulfoxaflor hit the US market in 2013. Beekeepers and environmental groups challenged the US Environmental Protection Agency's approval, claiming that the pesticide acts like the neonicotinoids imidacloprid and clothianidin and is just as harmful to bees. The EPA banned sulfoxaflor in 2015 after a federal appeals court order. One year later, the agency allowed the pesticide to be used on a few crops that don't attract bees.

In 2019, the EPA allowed new uses of sulfoxaflor on alfalfa, corn, sorghum, and several other crops. It also removed some restrictions it had put in place in 2016. "The EPA has adequate data to demonstrate that there will be no unreasonable adverse effects to honey bees resulting from the expanded registration of sulfoxaflor," the agency says in the 2019 registration notice.

Beekeepers, represented by the environmental group Earthjustice, sued the EPA in September 2019 for allowing sulfoxaflor back on the market. The case is pending in the Ninth Circuit Court of Appeals.

A combo for sugar beets

In California's Imperial Valley, sugar beet growers are looking for alternatives to chlorpyrifos to control flea beetles, beet armyworms, and other pests.

DPR is funding a project that involves treating seeds with neonicotinoids and pyrethroids while treating soil with an insecticide before seedlings emerge. Stephen Kaffka, an extension agronomist and specialist at UC Davis, is leading the effort.

The project will test seeds treated with Poncho Beta, a Bayer formulation of the neonicotinoid clothianidin and the pyrethroid β-cyfluthrin, Kaffka says. In addition, Coragen will be added to the soil before seedlings emerge. Coragen contains the active ingredient chlorantraniliprole and is marketed by FMC as nontoxic to birds, fish, and mammals.

"Poncho Beta is not that good on armyworms," but Coragen is, Kaffka says. "The hope is that the two in combination would work for growers and maybe not require additional applications" after seedlings emerge, he says.

"We will be scouting these plots," looking for signs of insect damage, Kaffka says. If a breakout occurs after the seedlings emerge, pyrethroids and other insecticides could be used, he says.

Kaffka considers the neonicotinoid seed

"If we have a good natural enemy in our citrus orchards controlling the target pest, then we don't need to use insecticides as frequently."

—Mark Hoddle, biological-control specialist, University of California, Riverside

treatment a reduced-risk option compared with spraying chlorpyrifos. He doesn't anticipate much of a risk of harming bees, because sugar beets in the Imperial Valley are planted in the fall and harvested in the spring. "They don't flower, so there is no pathway to the environment for neonicotinoids in beets," he says.

"Neonicotinoids are not appropriate for all problems, but they can be very effective in the right situations," says Kelley Tilmon, an Ohio State University entomologist with expertise in field crops such as corn and soybeans.

"Many formulations are applied as a seed treatment or a drench targeted at the roots, which is then taken up by the plant and distributed systemically inside the plant," Tilmon says. "This is very convenient and logistically easier than spraying and results in less worker exposure," she says. Also, less product is used compared with topical spraying.

However, neonicotinoids and most pyrethroids are not effective against spider mites, which are a common soybean pest, Tilmon says. Chlorpyrifos is useful for controlling spider mites in soybeans, she says. It is still allowed in midwestern states where soybeans are grown. But newer pesticides that specifically target mites are available. "They cost more than generic chlorpyrifos, but they are probably more effective and are a good choice for this type of problem," Tilmon says.

It remains to be seen how much chlorpyrifos will be available in the US next year after Corteva stops production. Generic versions are available, but it is unclear whether there will be enough to meet demand. Remaining demand may also disappear soon, pending a court ruling or who wins the presidential election.

In response to a 2007 petition from environmental groups, the EPA proposed to ban chlorpyrifos on food crops in 2015, citing neurodevelopmental effects in children. But the Trump administration reversed that decision in 2017, stating more research is needed to determine neurodevelopmental risks. Environmental groups, led by Earthjustice, challenged the EPA's reversal. The case is now pending in the Ninth Circuit Court of Appeals.

"We argued the case at the end of July," says Patti Goldman, managing attorney of Earthjustice's Northwest regional office. "We are expecting a ruling any day."

Growers may grumble at the forced change from a familiar broad-spectrum insecticide to new products that are more targeted, but in the long term it may be for the good. "Many of these newer chemistries are safer or easier to work with," Tilmon says. ■